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An Economic Assessment of the Freeze on Program Yields

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Abstract

This paper analyzes the economic consequences of the freeze on program payment yields which was introduced in the Food Security Act of 1985. It appears that this policy change reduced variable input usage in wheat production, while raising market prices and net returns. Estimates for a hypothetical 1991 crop year indicate that unfreezing program payment yields would have the opposite effect of raising variable input usage and output, while depressing prices and net returns. A preferable alternative for adjusting program yields would be to index them. This option would raise net returns while avoiding the negative environmental consequences associated with unfreezing program payment yields.

Keywords: Program payment yields, wheat program, policy modeling

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Contents

Summary

An important but often overlooked provision of the Food Security Act of 1985 was the temporary freeze on program payment yields for grains and cotton. Rather than annually updating these established yields, the Government froze the yields for 2 years at their existing level, which was the average of 1981-85 proven yields. The freeze was subsequently left in place for the remainder of the Food Security Act of 1985. Commodity groups expressed an interest in unfreezing program yields as part of the 1990 farm bill. This received serious consideration, but the bill that was signed into law left the freeze in place.

The unfreezing of yields would increase crop production by encouraging farmers to consider the target price when making their variable input decisions. Increased yields translate into more output, lower market prices, and higher program participation rates. A somewhat surprising consequence of unfreezing yields is the effect on net returns. Because the increase in revenue is less than the increase in variable expenses, we find that unfreezing yields lowers net returns and, thus, lowers returns to the residual claimant--land.

The consequences of program yield policy for the distribution of income between program participants and nonparticipants is also examined in this report. A freeze on program yields tends to benefit nonparticipants because it reduces output and raises market prices. Conversely, when program yields are unfrozen, nonparticipants are hurt by the subsequent fall in market prices.

Reverting to a policy that links future program payment yields with current yields has several other secondary consequences that appear unattractive. First, such a policy would increase the use of chemical inputs in agriculture at a time when environmental groups are pressing for "lower input" agriculture. Second, by stimulating output, the policy would place greater pressure on the Federal budget. The export-promoting, price-depressing effects of such a move would also run counter to current U.S. efforts at the General Agreement on Tariffs and Trade (GATT) negotiations in Geneva. There, the United States is pushing for the removal of domestic policies that promote excessive production of farm commodities. Had the program yields been unfrozen, the United States could have been viewed as "backsliding" in these trade negotiations.

If target prices are on a downward trend, frozen program yields translate directly into declining deficiency payments. If Congress wishes to offset these declines, there are alternatives that are preferable to unfreezing program yields. For example, program yields could be increased using an index unrelated to individual farm decisions. If program yields remained frozen, such an alternate policy would not have the undesirable consequences listed above. Furthermore, indexing yields would be a much more effective means of raising farm incomes.

An Economic Assessment of the Freeze on Program Yields

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Paul V. Preckel

Introduction

Deficiency payments for grains and cotton have been in place since 1974. They have grown to become a dominant item on the Federal agricultural budget, reaching a peak immediately following implementation of the Food Security Act of 1985. As deficiency payments have risen, increased attention has focused on their consequences for the pattern and intensity of agricultural production. Per-bushel deficiency payments are made based on the product of established yields and base acreage. Before 1985, established yields were updated annually by means of a 5-year moving average. Thus, documentation of higher yields in the current year contributed directly to increased payments for program participants in future years. This led economists to hypothesize that deficiency payments contributed to an excessive intensification of production, particularly since program participants are required simultaneously to idle productive acreage.

The Food Security Act of 1985 took a significant step toward unlinking target prices from actual yields by freezing program yields at their 1981-85 average. This was a temporary measure, legislated for the first 2 years of the act, with the policy for the remaining 2 years placed at the discretion of the Secretary of Agriculture. This freeze had little effect in the first year or two. Program yields had always lagged behind expected actual yields, and so a 1- or 2-year freeze was less noticeable.

In fact, many farmers and county Agricultural Stabilization and Conservation Service (ASCS) offices continued to operate as if the current yield information would eventually be brought into the established yield average. That is, actual yields were documented by farmers and recorded with local ASCS offices.

However, with the passage of time, the program yield freeze has taken on increased significance. After 1985, current yields were not incorporated into the electronic ASCS database. More recently, local offices ceased to accept yield information from farmers. Precisely because the program yield freeze had begun to look more permanent, farmers and commodity groups became more concerned with this aspect of the act. As a consequence, there has recently been increased discussion of "unfreezing" program yields. A first step in this direction was taken in the summer of 1989 when legislation was introduced which would have required ASCS to begin accepting current yield information once again (H.R. 2042). However, the 1990 farm bill signed into law left yields frozen at levels established by the Food Security Act of 1985.

Despite the long-term importance of the freeze on program yields, little economic analysis of this issue has been made. Existing quantitative models of the grains sector are not designed to take into account this type of structural change in the farm programs. To explore the diverse dimensions of

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this subject, we have developed a new model unique in its treatment of producers as a heterogeneous population, to be used as an analytical framework for the problems of program participation and crop production. Technical details for the model are provided in the appendix.

Problem Statement

This paper proposes, as its basic premise, the importance of considering how the freeze on program yields differentially affects the decisions of individual farmers in diverse circumstances. First, consider the case of a farmer who was participating in the program before the 1985 freeze. As long as the local ASCS offices were not recording proven yields, producers had little incentive to look beyond the market price in making marginal production decisions. However, the target price--and the expected deficiency payment--still plays a role in determining whether or not this farmer will choose to stay in the program.

The extent to which program participants' nonland input use and yields respond to the freeze depends critically on the potential for substitution between nonland and land inputs. This vitally affects the extent to which farmers individually--and as a group--alter their activities in response to market signals that change the expected price of grain, relative to variable input costs. If this response is large, the freezing of program yields takes on great significance. If set-aside requirements are not altered, then reduced participant production in response to the freezing of yields will raise market prices. This, in turn, has two less direct effects. First, nonparticipants now face a higher incentive price for their output. This tends to raise nonland input use on nonparticipating farms. Secondly, if the market price is already above the loan rate, expected deficiency payments fall, reducing the incentive to participate.

The impact of freezing program yields on total nonland input use and sectoral output is ambiguous. Participants use fewer inputs to produce less output, but nonparticipants do the opposite. To add to this ambiguity, participants who leave the program plant more acreage. Furthermore, the relative strength of these opposing effects is likely to change with changes in the prevailing market and program conditions.

The Analytical Framework

The above discussion shows that any model that refers simply to a "representative" producer will not be adequate (16).[1] At any given time, some producers are participating and some are not. The response of program participants to unfreezing program yields is qualitatively different from that of nonparticipants. To the extent that they differ along other important dimensions (for example, productivity), this phenomenon may be accentuated. In short, a framework is needed that recognizes the inherent heterogeneity of producers and uses it to explain voluntary participation behavior. There are many reasons why some producers choose to participate in commodity programs while others do not. In this paper, we focus on two particular features that distinguish grains producers: (1) the physical characteristics of the land they control, and (2) the transactions costs they must incur to participate in the program.

The Heterogeneous Land Base

Given the structure of the U.S. grains programs, the distribution of land on a given production unit is intimately related to the decision to participate in the program.[2] If the production unit includes some very poor land (land with

[1]Underscored numbers in parentheses refer to citations listed in the References.

[2]Since participation decisions are made on the basis of ASCS farm records, not economic farming enterprises, we chose to use the term "production unit" to describe the parcel of land in question.

a low "capacity" in our terminology) which can be "set aside" under program requirements, then the cost of participation will be relatively low and the incentive to participate will be high. We assume, for simplicity, that the distribution of land capacities on any given production unit is uniform. That is, the acreage base is evenly distributed over the range from minimum to maximum capacity. Thus, the greater the range of capacities, the more heterogeneous is the acreage comprising a given production unit and, hence, the greater the incentive to participate.

Next, we arrange producing units according to a homogeneity index r, which ranges from zero to one. Thus, r = 0 denotes the most heterogeneous (that unit with the greatest range of capacities) and r = 1 denotes the most homogeneous producing unit. This index may also be interpreted as a measure of the pro-pensity to stay out of the program because a larger value of r is associated with more homogeneous land and a higher opportunity cost of participation.[3] In any given year, there will be some cutoff point, r*, at which all producing units with a homogeneity index in excess of r* will be out of the program, and all units with a value of r less than or equal to r* will be in the program. In effect, r* is closely related to the participation rate (that is, acreage in the program divided by total acreage devoted to a given crop).

Those producing units for which the set-aside requirement is not very costly (low r) will tend to participate, even when expected deficiency payments are relatively low. As program benefits increase, for example, due to a hike in the target price, these producing units will not only stay in the program, but they will reap "windfall" gains. Meanwhile, some producing units not previously enrolled will find it profitable to idle acreage and enter the program. However, there comes a point when the costs of participation are equally as large as the expected benefits. We call this the "indifference point." Logically this point occurs at r*, since all units with a greater incentive to participate (r < r*) are enrolled in the program because the benefits outweigh the costs, and all units with a lesser incentive to participate (r > r*) are out of the program because the costs of participation exceed the benefits.

A very important issue has to do with the relationship between the homogeneity index r and the average capacity of a producing unit. In particular, it would be useful to know whether the first units to enter the program are more productive or less productive than other farms. If such units have a higher average capacity, then enrolling them in the program will affect output more significantly than if heterogeneous units are relatively unproductive. This relationship between average capacity and homogeneity is specified in a general way, which permits it to be either increasing or decreasing over any given range of r, depending on the historical evidence.

The Decision Problem

Given the land base described above, the first question is: What crops will be produced? We have chosen to ignore that aspect of the problem and assume that all of the acreage will be either: (1) planted to a given crop (for example, wheat) or (2) idled under the Government program for that crop. This assumption permits us to focus on the intensification effect of unlinking current production from future program yields, which is at the heart of the freeze question. A later section of this paper discusses the implications of introducing acreage mobility among alternative uses.

<u>Variable Input Use and Yields</u>

Within the single-commodity framework, we characterize the individual farmer's decision problem as a two-step process. The farm manager must look at two different scenarios. In the first scenario, the production unit under

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[3]Since producers may choose to take the county average as their program yield, another source of incentive for participation arises if the production unit has a low yield, relative to that which can be obtained from the local ASCS office. We explore the role of participants who do not prove their yields later in this paper.

consideration is not in the Government program, and only market signals are relevant. We aggregate all nonland inputs into two categories: fixed and variable inputs. Furthermore, to facilitate our analysis of the rate of variable input use, we assume that fixed factors (such as capital equipment) are in adequate supply and do not constrain production decisions in the short run. As a consequence, the manager's production decision amounts only to determining the level of variable nonland inputs purchased and applied to a given amount of acreage of a particular quality. We presume that, as the market price rises, more fertilizer and chemicals will be applied, and additional field operations may also be employed. The degree to which prices may affect fertilizer application and field operations depends on how responsive farmers believe yields to be. This relationship, in turn, is determined by the elasticity of substitution between variable inputs and land. This elasticity is another parameter that we attempt to estimate, based on observed data.

In the second scenario, the farmer chooses to enroll in the Government program. Hence, the production decision is somewhat more complex. When the farmer visits the local ASCS office and determines precisely what the program requirements are in that year, and provided the production unit in question has an established base, the manager must determine which land will be idled to satisfy the acreage reduction requirement.[4] (There are now also a host of other alternatives such as the 0-92 option, overplanting, and the planting of soybeans on base acreage. We will ignore these alternatives in order to simplify the discussion.) As noted above, we expect the farmer to idle the least productive (the lowest capacity) land.

Once the manager has determined which land to plant, the production decision is handled in a manner like that of the nonparticipants. The intensity of production, that is, variable inputs and, hence, yields, is determined by the price received on the marginal bushel of output relative to the price paid for variable inputs. The central issue in this paper revolves around the question of what output price participating farmers have in mind when making this decision. Is it the target price, the market price, or some combination of the two?

In any given year, program payments are predetermined by the product of program yields and program acreage. However, before the freeze on program yields, current yields were clearly linked to future program payments. In particular, high yields in one year served to raise the 5-year moving average used to calculate program yields over the next 5 years. If one assumes that a given farmer plans to stay in the program indefinitely, then the incentive effect associated with a given target price may be calculated as a weighted combination of the market and target prices: $Z * PT + (1-Z)PM$. The weighting factor (Z) is equal to $(1/5)/(1/5 + D)$ where 1/5 is the amount that is contributed to the moving average in any given year and D is the farmer's real discount rate (<u>4</u>, ch. 2). Thus, if future receipts are not discounted, then $D = 0$, $Z = 1$, and the incentive price is the target price. If they are discounted at a real interest rate of 10 percent, then $Z = 2/3$, and the market price comes into play. For convenience, we will begin by assuming $Z = 1$ (in the absence of a freeze). This assumes that participants consider the target price as the relevant supply price in making purchased input decisions. To the extent that some participants discount future benefits, they will use a weighted combination of the target and market prices, and our results will overstate the impact of the freeze on variable input use and yields. Later we will vary Z to study the sensitivity of our results to this parameter.

Finally, there are intermediate categories of producers besides the typical participants and nonparticipants. For example, participants can be distinguished between those who "prove" their yields and those who do not. The latter group simply receives the county average yield (or some variant thereof) as their program yield. These "nonprovers" have no cause to use the target price as an incentive price. Conversely, some nonparticipants choose to stay out of the program this year and "build base" in anticipation of

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[4]At one time, this idled land had to be rotated, but that is not currently the case.

future entry into the program. For these producers, the target price is likely to play a role in determining variable input use and yields. Unfortunately, the available data are not specific enough to justify attempting to treat either of these intermediate cases in our estimation of the model. However, when we analyze the consequences of a freeze, we will conduct some sensitivity analysis to help suggest the probable effects of these other groups.

Transaction Cost and the Participation Decision

Having evaluated returns, net of variable costs, both in and out of the program, the farmer is in a position to decide whether or not to participate. We believe that "transaction costs" represent a significant deterrent to program participation. These include the costs of establishing base acreage, recording current yields, complying with conservation requirements, becoming informed about the current year's programs, and handling the accompanying paperwork. Also, some farmers find receiving a Government check distasteful. As a consequence, even when the Government programs are extremely generous, such as in the 1986 crop year, program participation is far from universal.

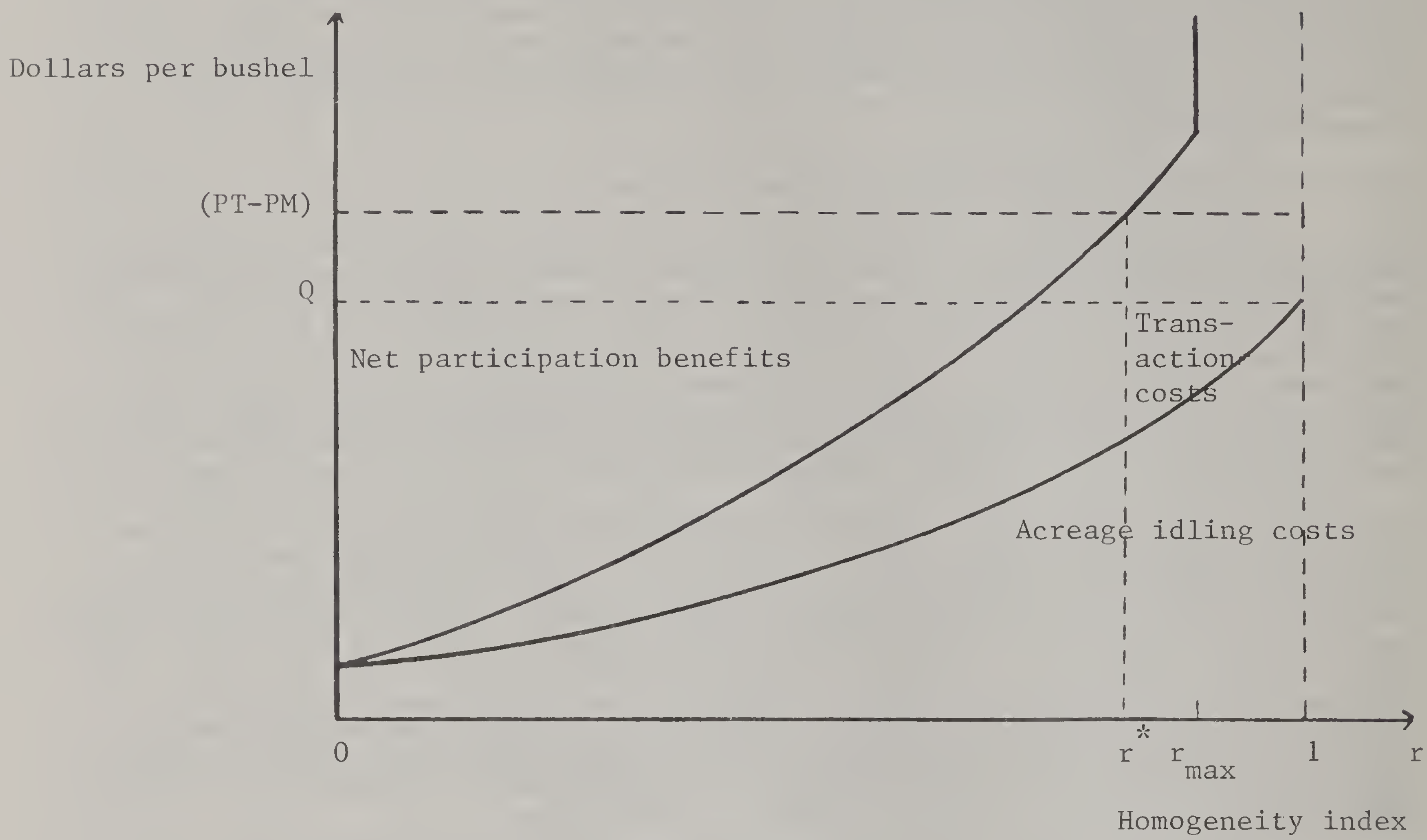
We expect total transaction costs to be relatively invariant to the size of the participating production unit. Thus, larger producing units will have lower per-acre transaction costs. Since we also expect farm size to be inversely related to the homogeneity of the production unit, transaction costs per acre are expected to be positively related to r. Thus, at low levels of participation, per-acre transaction costs for participants are also low. As participation rates rise, however, the farms newly entering the program have higher per-acre transaction costs. Eventually, transaction costs become prohibitive. At this point, some farms will never enter the program. The rate at which these costs increase will be determined by observing historical participation rates in light of program incentives.

In our framework, farms will enter the program as long as profits "in the program," minus transaction costs, exceed profits "out of the program." In equilibrium, there will be some farms that are indifferent to being in or out of the program. As stated earlier, we label the associated homogeneity index r^*, and all production units with a value of $r \leq r^*$ are expected to be in the program. Conversely, all of those with $r \geq r^*$ are expected to be out of the program. This critical value, which we use for distinguishing participants and nonparticipants, varies as a function of program parameters and market conditions. With a generous program, we expect a value of r^* approaching one. By contrast, as expected deficiency payments shrink, r^* approaches zero.

The hypothesized expected costs and benefits from program participation are shown in figure 1. These are placed on a per-bushel basis and are then plotted against the homogeneity index (r). On extremely heterogeneous producing units, the opportunity cost of idling the poorest land is relatively low. This increases with r (the lower cost curve in figure 1) and reaches Q dollars per bushel when r = 1. Since the expected deficiency payment (PT-PM) exceeds Q, we expect 100 percent participation in the absence of transaction costs. Historically, this was essentially the case immediately following passage of the Food Security Act of 1985. At that time, with expected deficiency payments for wheat approaching $2 per bushel, extension specialists were counseling all eligible farms to participate in the program. Yet, this advice ignored transaction costs. In the next section of this paper, we estimate the magnitude of the discrepancy between expected benefits and expected costs, and attribute it to transaction costs. Of course, at some point (r_{max}), all eligible acreage will be enrolled in the program and the transaction costs function becomes vertical. The indifference point (r^*) is found by equating the benefits from participation with the sum of idling and transaction costs. This point will never lie to the right of r_{max}.

The next section of this paper discusses the approach taken in choosing the parameters associated with the land distribution, the production function, and the transaction costs function. The U.S. wheat sector has been selected for this initial application, although this framework could be applied to other program crops as well.

Figure 1 Hypothetical costs and benefits from program participation



Development of a Wheat Model

Estimation of the model outlined in the previous section is complicated by many factors. First of all, the distribution of land capacities is fundamentally unobservable. What we typically observe are yields for a given production unit. If, however, the level of nonland inputs applied is known, production capacity may be inferred from yields. Unfortunately, national data on both nonland input use and the associated yields for the same farm are not available. Furthermore, national input use data for a specific commodity, such as wheat, are very difficult to obtain. Many farms grow wheat in conjunction with other crops, and their fixed inputs must be "allocated" among products if one is to obtain commodity-specific data. USDA's cost of production surveys, which are done for specific commodities about every 4 years, make such allocations, and this is the data source we use here.

Given these data constraints, we chose to fit the model to data from the 1978, 1982, and 1986 crop years. The appropriateness of including 1986 in our data is debatable. The Food Security Act of 1985 was passed in December 1985, which was after the winter wheat crop was planted but before the planting of the spring wheat crop. The provision for a freeze on program yields was entered late in the debate over this bill and was portrayed as a temporary measure. Since yields have always been updated in the past, we believe that many farmers did not immediately respond to this freeze by adjusting nonland input use because many farmers continued to report yields, despite the freeze legislation.

The data we use are presented in table 1. They include information on the U.S. wheat program, the expected market price of wheat, aggregate production levels (both actual and weather-adjusted), variable input use, participation rates, and the distribution of production between participants and nonparticipants. (The latter is inferred from observed deficiency payments

Table 1--Wheat facts for selected crop year

Item	Unit	1978	1982	1986
Program variables:				
Loan rate	Dollars per bu.	2.35	3.55	2.40
Target price	do.	3.40	4.05	4.38
Expected market price[1]	do.	2.92	3.80	2.54
Set-aside requirement	Percent	20.00	15.00	22.50
Paid land diversion (PLD)	do.	0	0	6.00
PLD payment	Dollars per bu.	0	0	1.55
Participation rate (in terms of acres)	Percent	63.49	42.03	73.26
Participants' planted acreage share	do.	58.17	38.13	66.21
Total land in sector	Million acres	75.60	92.00	91.00
Planted acreage	do.	66.00	86.20	72.00
Total production	Million bu.	1,775.50	2,765.00	2,087.00
Production adjusted for weather[2]	do.	1,846.16	2,765.00	2,247.07
Average yield per planted acre	Bushels	26.90	32.08	28.99
Variable cash expenses per planted acre	Dollars	28.33	53.66	45.94
Variable expenses deflator	Index	.66	1.00	.92
Expenses/deflator ratio	Ratio	42.92	53.66	49.93
Total Government payments	Million dollars	[3]617.00	[3]475.00	[4]3,688.00
Observed deficiency and diversion payment rate per bushel	Dollars	.52	.50	2.11
Implied participants' production (weather adjusted)	Million bu.	1,233.79	950.00	1,881.92
Participants' production share	Percent	66.83	34.36	83.75

[1]The expected market price is defined as the average of closing prices on contracts with a September delivery date, for every Thursday in February, March, and April.

[2]Actual production adjusted for normal weather conditions, based on estimates of Ash and Lin (1).

[3]Deficiency payments.

[4]Deficiency payments and diversion payments.

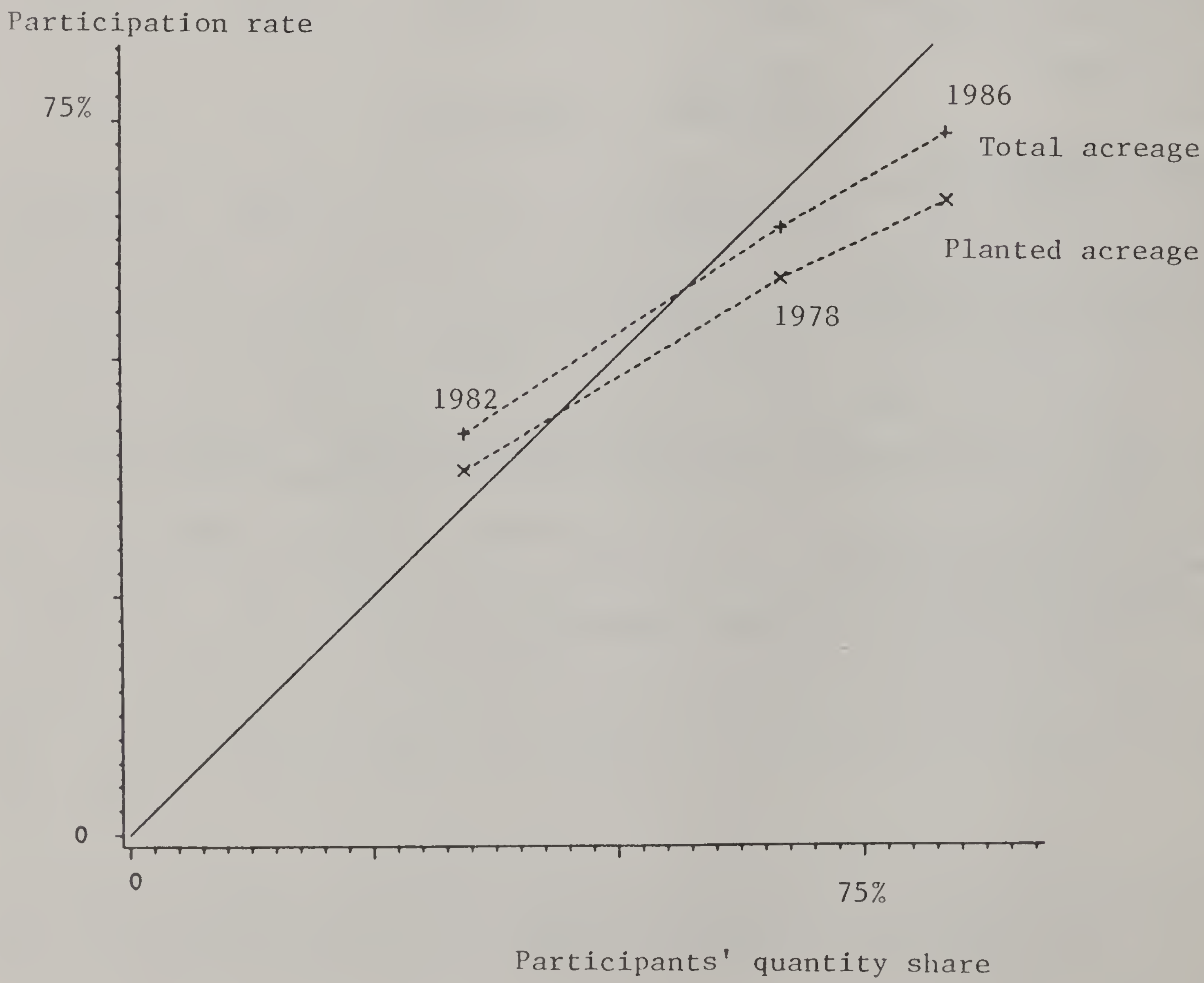
Sources: (2,11,12,14).

and the average payment rate per bushel.) We control for the effects of weather and technological change, following the work of Ash and Lin (1).

Since the available data are quite limited and the model--despite all of the simplifying assumptions--is rather complex, our estimation procedures are necessarily crude. We prefer to describe our approach as one of "fitting" the model to the data. (Details are available in the appendix.) The fitted parameters do not have any of the usual statistical properties. Rather, we use the model as a "lens" for interpreting aggregate data from these 3 different years. Each point in figure 2 represents a combination of the participation rate and the participant's output share in the 3 years under consideration. In 1982, the participation rate--as measured by acreage in the program divided by total wheat acreage--was 42.03 percent (table 1). When measured as a percentage of planted acreage, this was 38.13 percent. By contrast, the share of output from these participating producers was only 34.36 percent (table 1). As a consequence, in 1982, participants produced a disproportionately small share of the total wheat crop. In 1978 and 1986, the opposite was the case. In those years, participants accounted for a disproportionately large share of output. This outcome is particularly striking in the 1986 crop year when participants controlled only 66.21 percent of the planted acreage, yet they accounted for 83.75 percent of the wheat production.

Taken together, the data plotted in figure 2 imply a relationship between mean productive capacity and the propensity of producing units to participate in the wheat program. In particular, the average capacity of producing units

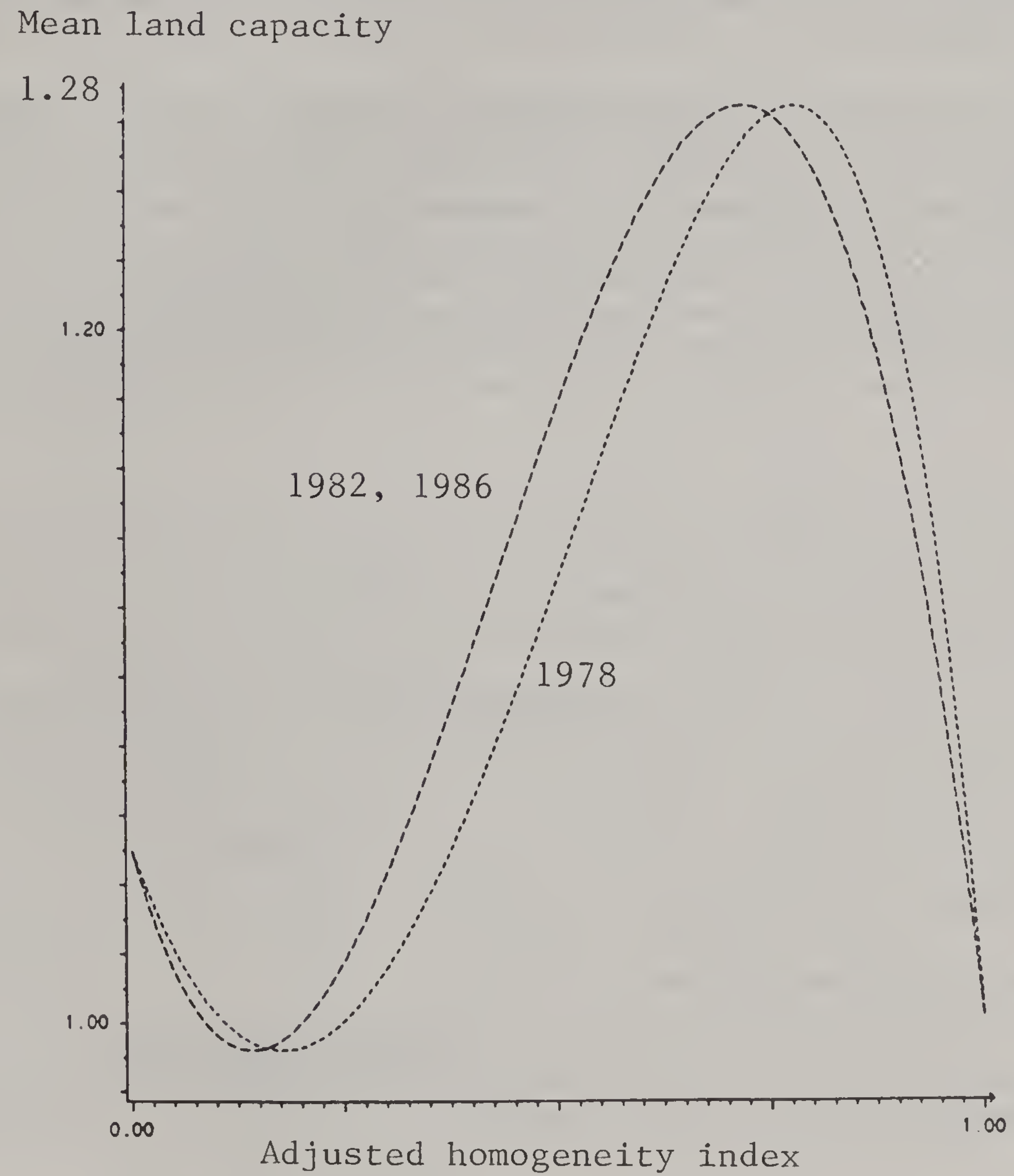
Figure 2 Relationship between participants' share of wheat production and acreage controlled



must be rising over the range $0.42 < r < 0.73$. This situation is shown in figure 3, which plots mean capacity for the fitted model.[5] Furthermore, if participants account for a disproportionately large share of total output when $r^* = 0.73$ (as they did in 1986), then nonparticipants in that year ($0.73 < r \leq 1.0$) must account for a disproportionately small share of output. Hence, a dramatic fall occurs in mean capacity over this range of r, as displayed in figure 3.

The phenomenon of falling mean capacity at high levels of r may be further understood by returning to the issue of farm size. Empirical evidence indicates that scale economies are most pronounced for small farms, with the average cost curve flattening out at moderate levels of output. These small operations are also likely to be the most homogeneous. Since we have not introduced economies of scale into the wheat production function in our model, we expect the inferred distribution of land capacities to pick up some of these effects, especially at high levels of r. In particular, mean capacity must fall to reflect the lower economic efficiency of the smallest operations.[6] The distribution of land capacities in figure 3 refers to all wheat acreage, not planted acreage. By choosing to participate in the

Figure 3 Distribution of land capacity



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[5]Between 1978 and 1982, more than 16 million acres of land came into wheat production. We have reason to believe that this changed the shape of the land distribution (6, 15). As a consequence, we permit the distribution of land capacities to shift between these 2 years. This results in a shift in the plot of mean capacities in figure 3.

[6]For our purposes, the observational equivalence of land capacities and scale economies is not particularly problematic. We are primarily concerned with the relative output shares of participants and nonparticipants. The possibility that, at high levels of r*, nonparticipants are contributing a relatively small share of output due to their relatively smaller size is of secondary importance. Of course, any attempt to look at a longer time series of data would need to take explicit account of the changing distribution of farm size.

set-aside program, farmers are able to raise the mean capacity of planted acreage. This phenomenon is illustrated in table 2 which reports the characteristics of the marginal program participant in 1982 as estimated by our model. In the first column are the figures that are applicable if this production unit were enrolled in the 1982 wheat program, while the second column reports comparable information if the production unit were out of the program. In this second case, 15 percent of the farm would be idled. But, because this is the worst land, mean capacity for planted acreage is higher (1.16) than it would be if the farm were out of the program (1.02).

In the absence of a yield freeze, program participants tend to look at the target price when making variable input decisions, and this means that nonland input use per planted acre is higher.

For the marginal participant, we estimate nonland input use to be roughly $7 per acre higher in the program than it would be out of the program. The magnitude of this response depends on the elasticity of substitution between variable inputs and land. Given the limited nature of our data on variable input use in wheat production, we cannot place much confidence in our specific estimate of this parameter (0.59). However, almost all of the qualitative results in this paper rely only on this being a positive number. This is similar to arguing that the supply of wheat from a given acreage base responds positively to price. Most agricultural economists would consider this to be a noncontroversial assumption.

The yield response to a higher incentive price, combined with a higher mean capacity per planted acre, translates into higher mean yields per planted acre (about 6 bushels per acre) if this individual unit chooses to enroll in the program and idle 15 percent of the land. However, by our definition of the marginal participant, net returns per acre are equal for the two alternatives ($73.01 per acre in this case). Furthermore, similar calculations for any farm with $r < 0.42$ would show higher net returns within the program. By contrast, production units with $r > 0.42$ show higher net returns out of the program, since their gains from participation do not outweigh the associated costs.

Table 2--Characteristics of the marginal participant ($r = r^* = 0.42$)

Variable	Optimal values (1982 crop year)	
	In the program	Out of the program
	Percent	
Proportion of production unit idled	0.15	0
Mean capacity index of planted acres	1.16	1.02
	Bushels per acre	
Mean yield on planted acres	35.66	29.75
	Dollars per acre	
Revenue per planted acre	144.43	113.05
Less costs per planted acre:		
Variable inputs	47.37	40.04
Transaction costs	11.16	0
Equals net returns per planted acre	85.90	73.01
Adjustment for set-aside acreage gives net returns per acre	73.01	73.01

Analysis of the Freeze

Having developed a model of the wheat sector that explicitly captures the inherent heterogeneity of producers, we are in a position to analyze the effects of a freeze on program yields. Since the model is estimated using data from the pre-freeze era, we have chosen to use it as an instrument for simulating the consequences of introducing a freeze on program yields. Simulation of the effects of unfreezing program yields results in a reversal of these effects.

Assumptions

As with any simulation experiment, some simplifying assumptions are necessary. First, we assume that the freeze is permanent and that this is known. Once the freeze is announced, all farmers recognize that current yields will not be reported and can in no way be used to influence future payments. Such was clearly not the case with the present yield freeze, as many farmers still believe that the Government will not let program yields get "too far out of line" with actual yields. Some of these farmers undoubtedly have been documenting current yields in anticipation of future legislation that would call for an updating of the 1981-85 average yields. (Their belief was confirmed by the recent move to begin recording current yields again.) This first assumption will provide results much more dramatic than anything that has actually been observed under the 1985 farm legislation.

Our second simplifying assumption pertains to the distribution of frozen program yields. In estimating the model, the distribution of program yields was approximated with the distribution of actual yields--thereby ignoring the lag effect caused by the 5-year moving average used to establish program yields. In simulating the yield freeze, we will maintain this assumption, but now the program yield distribution will be the distribution of yields that would have been realized had the freeze not been in effect in that year (the one that the model predicts for 1986, prior to this experiment).

Impact on the Sector

We present a variety of estimates in table 3. These are designed to illustrate the sensitivity of our results to different program conditions. First, we simulate the permanent freeze in two different crop years: 1982 and 1986. Table 1 showed that 1982 was a period of relatively strong market prices and modest participation rates, while 1986 was a year of much higher benefits and higher participation rates.[7] A second sensitivity analysis results from introducing the freeze in the case when some participants are nonprovers and $Z < 1$ (denoted case II to distinguish it from the base case I). In particular, we assume that: (a) $D = 0.10$, so that the participant incentive price for yield provers is (1/3)PM + (2/3)PT, and (b) participants who would be better off not proving yields and simply taking some average yield, do so.[8] Both of these features serve to dampen the effect of a high target price on variable input use. As a consequence, they also serve to dampen the effect of a freeze on program payment yields.

The immediate effect of a permanent, unanticipated freeze is to reduce optimal variable input levels for program participants, since they no longer consider the target price in making such decisions. This drop is particularly dramatic (-23 percent) in 1986 (case I) when the target price is assumed to be the

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[7]Even though the yield freeze was legislated midway through the 1986 crop year, we believe it did not have a significant impact on decisions actually taken in that year. To the extent that we are wrong, and the 1986 data already reflect partial adjustment to the freeze, the simulated results for 1986 will overstate the changes from observed values resulting from a permanent, preannounced freeze in that year.

[8]The specific procedure used here is to alter the 1986 equilibrium by introducing a value of $Z = 2/3$ and a second indifference condition whereby the marginal participant ($r = r_p^*$) is indifferent between proving and not proving yields. In the revised equilibrium, with program yields unfrozen, 19.77 percent of participants choose to take the national average yield in lieu of proving their own yield. (We have no county yield distributions, so we are forced to use national average yield for nonprovers.) The results in table 3 are the percentage changes from this revised equilibrium when a permanent freeze is introduced.

Table 3--Implications of an unanticipated, permanent freeze in program yields for U.S. wheat

Variable	Year of freeze: 1982 Case I (Z = 1)	1986 Case I (Z = 1)	1986 Case II (Z = 2/3 and nonprovers)
	Percent change		
Variable inputs:			
Per planted acre	-1.6	-23	-11
Total use	-1.3	-22	-10
Output (quantity)	-.5	-11	-5
Exports (quantity)	-.7	-16	-7
Participating acres	-5.1	-6	-4
Average annual return to land	.9	15	6

incentive price. In that year, the target price was far in excess of the market price for wheat. As a consequence of lower rates of variable input use, realized yields fall, and output, and hence exports, fall as well.

Lower wheat output raises market prices and induces some farms to leave the program. We project (case I) that participating acreage would have fallen by 6 percent or about 4.0 million acres. A secondary effect of this lower program participation rate is to increase planted acreage slightly (by 1.1 million acres). This increased acreage moderates the decline in total use of variable inputs, which fall by 22 percent.

Perhaps the most interesting shortrun consequence of the freeze on program yields is the subsequent rise in land rents. With inelastic shortrun farm level demand, the market price of wheat rises more than output falls.[9] Thus, sector-wide receipts from the marketplace rise. Receipts from the Government (deficiency payments) are determined by the product of three variables: (1) the frozen program yields, (2) program acreage (which declines only slightly), and (3) the difference between the target and market prices (which shrinks). Since Government payments fall by more than market revenues rise, total revenues to wheat producers fall. However, variable input expenditures fall even more. As a consequence, returns to the residual claimant on income--land--rise. The magnitude of this effect is negatively correlated with the change in land-substituting nonland inputs. Thus, it is strongest in 1986, when land rents rise by 15 percent (case I). However, all of these qualitative results also apply to 1982.

The final column (case II) in table 3 provides an indication of the sensitivity of our results to assumptions about discounting the target price and the presence of nonproving participants. As expected, the impact of the freeze on program payment yields is less dramatic when: (1) some participants are already using the market price as their incentive price, and (2) the remaining participants (the provers) are discounting the target price somewhat. However, the same qualitative conclusions apply in case II. In sum, aggregate usage of variable inputs, output, participation, and net returns all fall.

The results in table 3 reflect the shortrun responses to a permanent freeze on program yields. In the longer run, several additional dimensions come into play. First, as technological progress raises yields, we can expect the frozen program yields to fall farther and farther behind. This will tend to discourage participation which, in turn, will tend to raise output. As a

[9]We calculate the aggregate farm level demand elasticity for wheat (e) as a share-weighted function of the domestic and export demand elasticities: e = (1 - w) ed + (w)ex. We choose values for the first two parameters following (3): ed = -0.2 and w = 0.55. The shortrun export demand elasticity is based on (8): ex = -0.80, and, therefore, e = -0.53.

contrary factor, the longrun export demand elasticity is considerably larger than in the short run. This demand responsiveness will moderate the longrun market price increase following the reduction in U.S. wheat output. Another factor likely to moderate the market price change is the Secretary of Agriculture's discretion over the acreage reduction requirements. These requirements have been reduced in response to higher market prices in recent years. Such reductions increase output (although it also makes participation more attractive). Since the market price increase is the factor leading to the shortrun decline in participation, that change will also be moderated. Finally, wheat acreage response is an important factor. Over time, higher land rents will tend to draw additional acreage into wheat production if returns to alternative cropping activities are unchanged. This increased production will tend to moderate both the change in land rents and the longrun decline in wheat output.

Comparison with Observed Data

How do these results compare with what has actually happened in the last 4 years? This evaluation is difficult, given the host of other changes in policies and market conditions since the 1985 farm legislation was implemented. Changes in Acreage Reduction Program (ARP) requirements, the presence of the Conservation Reserve Program, volatility in both weather and market prices, as well as many other factors, are likely to swamp any observable output from the freeze. Ideally, we should examine variable input use or yields on participating wheat farms over the past 5 years. Lacking such data, we are forced to turn to information about average wheat yields for all producers.

Table 4 presents National Agricultural Statistics Service (NASS) estimates of average U.S. wheat yields over the period 1984-89. We have tried to control for the volatile weather over this period by using estimated historical relationships between yields and rainfall and temperature during critical periods of the crop year. The second column of table 4 presents the weather-adjusted yields. The final column also deflates observed yields to account for the trend rate of growth in yield potential, based on the historical impact of varietal improvement on wheat productivity. The adjusted yields do show some signs of declining, an observation that lends tentative support to our hypothesis that the freeze, however temporary, led to lower rates of variable input use and lower yields. Of course, there may be other explanations for these changes in adjusted yields and definitive conclusions await improved data.

Table 4--Average wheat yields

Year	NASS yields	Adjusted yields[1]	
		Weather	Weather and technology
	Bushels per acre		
1984	38.8	38.8	38.8
1985	37.5	38.1	37.5
1986	34.4	37.2	35.8
1987	37.7	39.2	37.3
1988	34.1	38.0	35.4
1989	32.9	[2]	[2]

[1]These columns adjust the NASS yields for the effects of weather and historical trends in yield potential, using statistical evidence from the period 1956-84 (1,9).
[2]Cannot be calculated with currently available data.

Distributional Consequences of the Freeze

Up to this point, the discussion of results has focused on the impact of the freeze on the wheat sector as a whole. However, our problem statement emphasized the importance of distinguishing among heterogeneous producers who may respond differently to the freeze. Table 5 groups wheat production units into three broad categories. The first includes producers who were nonparticipants before the freeze and also nonparticipants after the freeze. The second category includes producers who were marginal participants before the freeze and subsequently left the program in response to the rise in the market price of wheat. The final group includes those who were participants both before and after the freeze on program yields.

Group one unambiguously benefits from the freeze. Market price increases cause revenue to increase by more than variable expenses on nonparticipating acreage. As a consequence, residual returns in 1986 (case I) rose by $262 million. Since we hold aggregate wheat acreage constant, total acreage in this group is unchanged (24.33 million acres) and per-acre net returns increase by $10.77.

The second group's situation is more complex. Since these producers left the program, their planted acreage increased by 40 percent, or approximately 1.10 million acres. This acreage increase outweighed the yield effect of reduced variable input use. The latter effect follows from the fact that producers from the second group shifted their attention from the target price to the market price. As a consequence, receipts from the marketplace rise. This was also the group of participants for which program participation was most onerous, and the subsequent reduction in estimated transaction costs was not insignificant. Their returns increased in case I by $7.01 per acre.

Table 5--Distributional consequences of a permanent, unanticipated freeze on wheat program payment yields prior to the 1986 crop year: Case I (Z = 1 and all participants prove yields)

Item	Producer group 1: Nonparticipants Before	Producer group 1: Nonparticipants After	Producer group 2: Participants Before	Producer group 2: Nonparticipants After	Producer group 3: Participants Before	Producer group 3: Participants After
	Million dollars					
Receipts:						
Market	987	1,477	231	250	3,415	3,410
Deficiency payments	--	--	180	--	2,650	1,833
Total	987	1,477	411	250	6,065	5,243
Less costs:						
Variable inputs	615	843	187	141	2,834	1,846
Transactions	--	--	142	--	650	650
Equal net returns	372	634	82	109	2,581	2,747
	Million acres					
Total	24.3	24.3	3.9	3.9	62.8	62.8
Planted	24.3	24.3	2.8	3.9	44.9	44.9
	Dollars per acre					
Returns	15.3	26.1	21.3	28.3	41.1	43.7

-- = Not applicable.

The final group in table 5 benefited least from the freeze because receipts, both from the marketplace and from the Government, fell. However, variable expenses fell more, so returns, net of variable expenses and transaction costs, increased by a total of $166 million or an average of $2.67 per acre for the third group.

While it may seem counterintuitive that program participants would actually benefit from the freeze on program payment yields, the underlying principle can be easily understood by referring to figure 4, panel A. This first graph in figure 4 illustrates the case of a participant who: (1) does not discount the target price (Z = 1), and (2) faces a constant target price with a stable supply curve, such that actual yield (YA) is exactly equal to program yield (YP) prior to the freeze. In this case, the producer's total receipts from a planted acre (we abstract from the ARP requirements here, since they are present with or without the freeze), are equal to deficiency payments [YP * (PT - PM) = A + B] plus market receipts [YA * PM = C + D + E]. Variable expenses equal the area under the producer's marginal cost curve (MC), which is given by B + C + D, so that net returns per planted acre are equal to A + E.

Now introduce a freeze on program payment yields, such that participants are assured of receiving deficiency payments on YP regardless of what they actually produce. There is no incentive to prove higher yields than would be justified by the market price (PM). If the farm level demand for wheat were perfectly elastic, such that PM were fixed, then yield-proving participants would reduce yields from YP to YM. Assuming no change in the target price, participants would continue to receive the same deficiency payments. Receipts fall only by the area represented by C. Yet, costs fall by B + C. Thus, net returns rise by an amount equal to the triangle B.

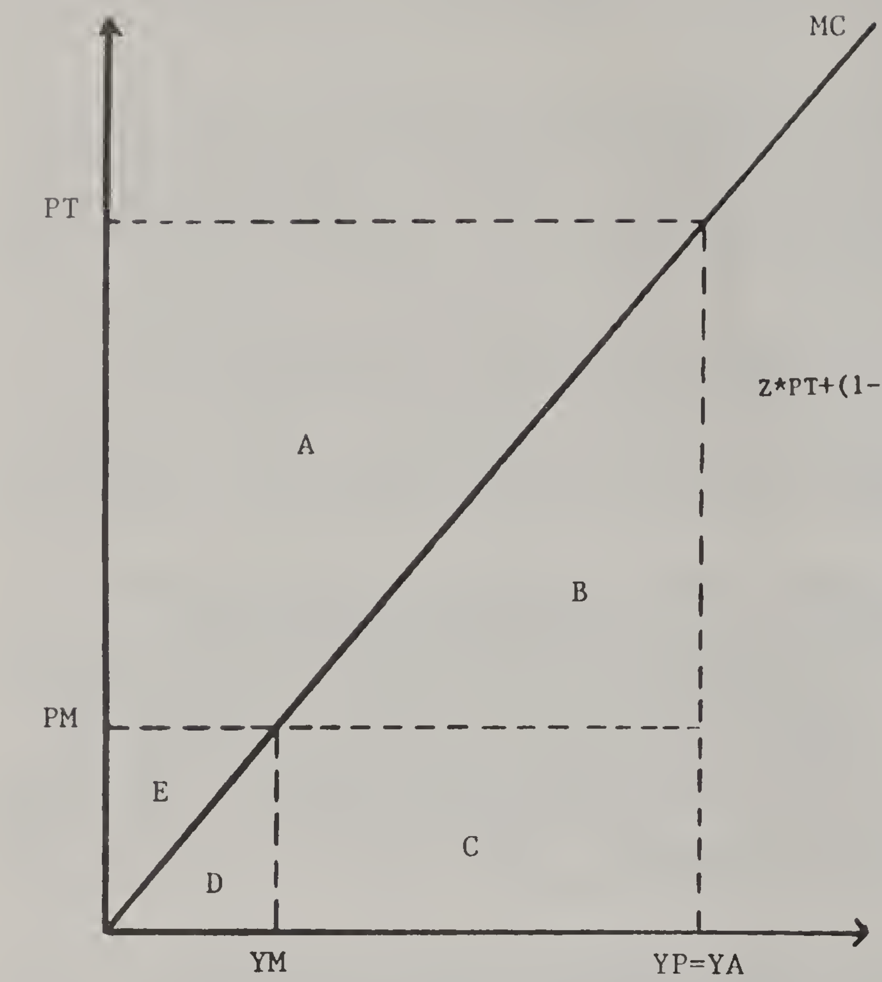
Figure 4, panels B and C illustrate how this same principle of costs falling faster than revenues also applies when participants discount deficiency payments and when proven yields lag behind actual yields. In figure 4, panel B, participants apply a 10-percent real discount rate to future deficiency payments so that the incentive price lies two-thirds of the way between PM and PT. In other words, producers apply variable inputs to planted acreage up to the point where marginal cost equals (2/3) PM + (1/3) PT. In this case, proven yields are lower than those in figure 4, panel A, as is the cost reduction under a freeze (B + C). However, this cost reduction still exceeds the loss of revenue by the area of the triangle denoted by B.

In figure 4, panel C, we have the case where deficiency payments are discounted and program yields lag actual yields (YP < YA) prior to the freeze. This situation might arise for a variety of reasons. For example, target prices may have risen relative to variable input costs or technological progress may have shifted the wheat supply function to the right. In any case, participants are found at a point where they are actively attempting to raise proven program yields. In this case, revenues prior to the freeze equal A1 + A2+ B1 + C1 + C2 + D + E, while costs are given by B1 + B2 + C1 + C2 + D. When the freeze is implemented, costs fall by B1 + B2 + C1 + C2, while revenues fall by C1 + C2. Thus, net returns rise once again.

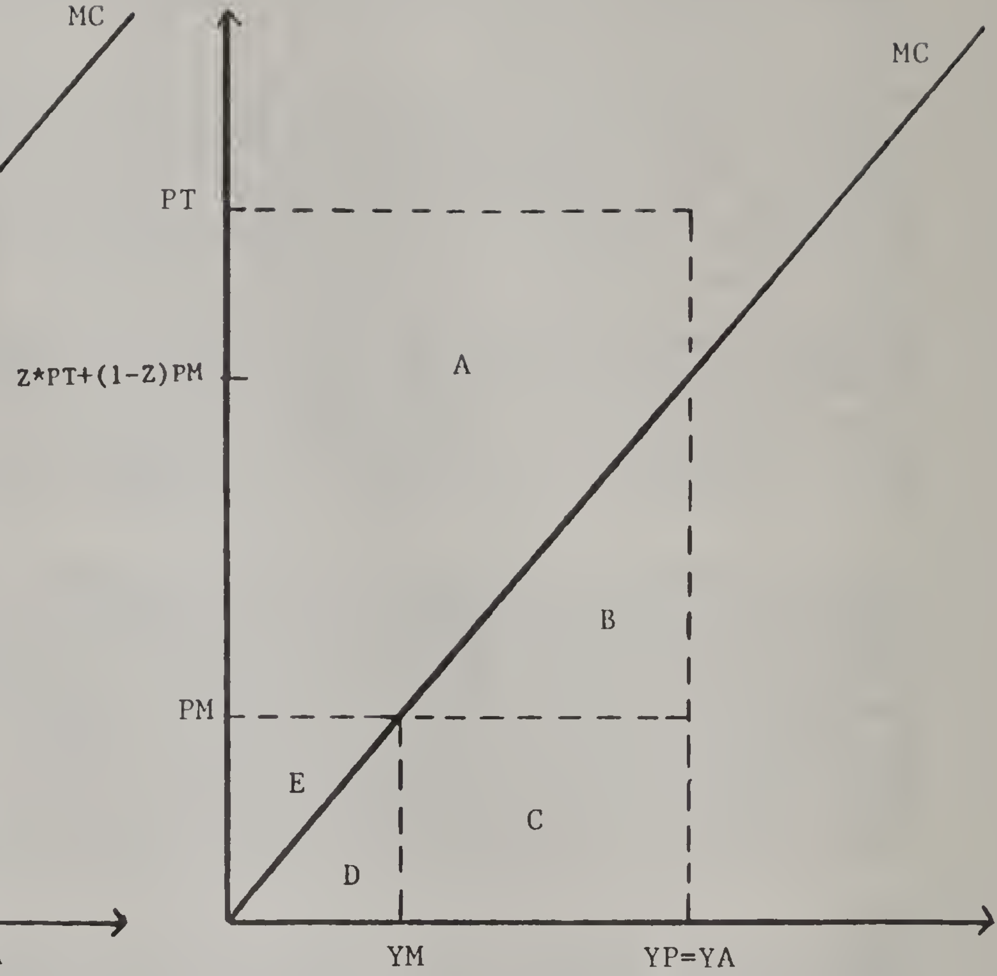
While figure 4's panels A-C illustrate why net returns will always rise for participants who choose to prove their yields, we have not yet addressed the role of nonproving participants. This is the focus of figure 4, panel D. The producer represented in panel D has very poor land that is not very responsive to variable inputs. As a consequence, the marginal cost curve is quite steep (MCN) and results in lower yields at any given price. For this reason, the producer depicted here has chosen to consistently adopt the county average yield (YP) rather than proving actual yield. This means that the market price has already been the incentive price for this producer, and actual yields (YA) equal YM. Prior to the freeze, revenues per planted acre are given by A' + A + B' + B + D + E, and costs are only equal to D.

When the freeze is implemented, the nonprover is unaffected as long as the market price is unchanged. However, since yield-proving participants reduce variable input use and output, market prices actually do rise (here, to PM'). This shrinks the nonprovers deficiency payments by (PM' - PM) * YP, while

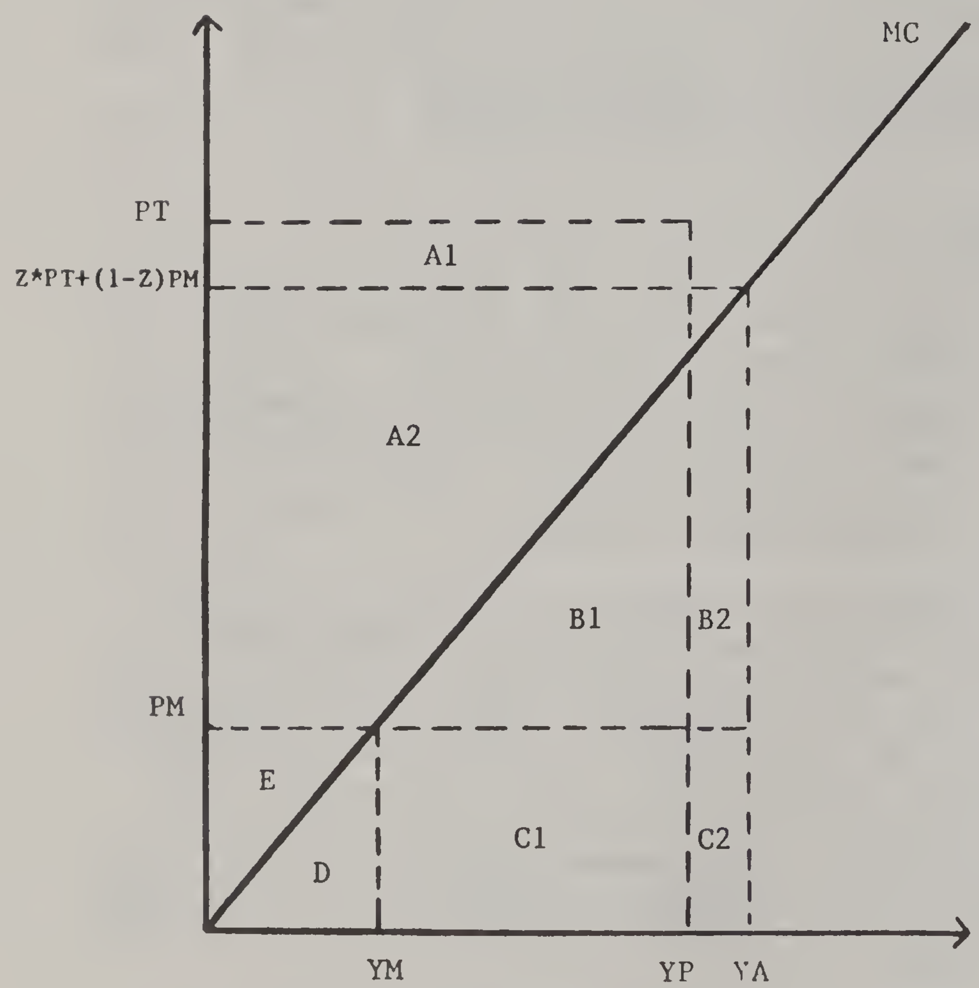
Figure 4 Program yields



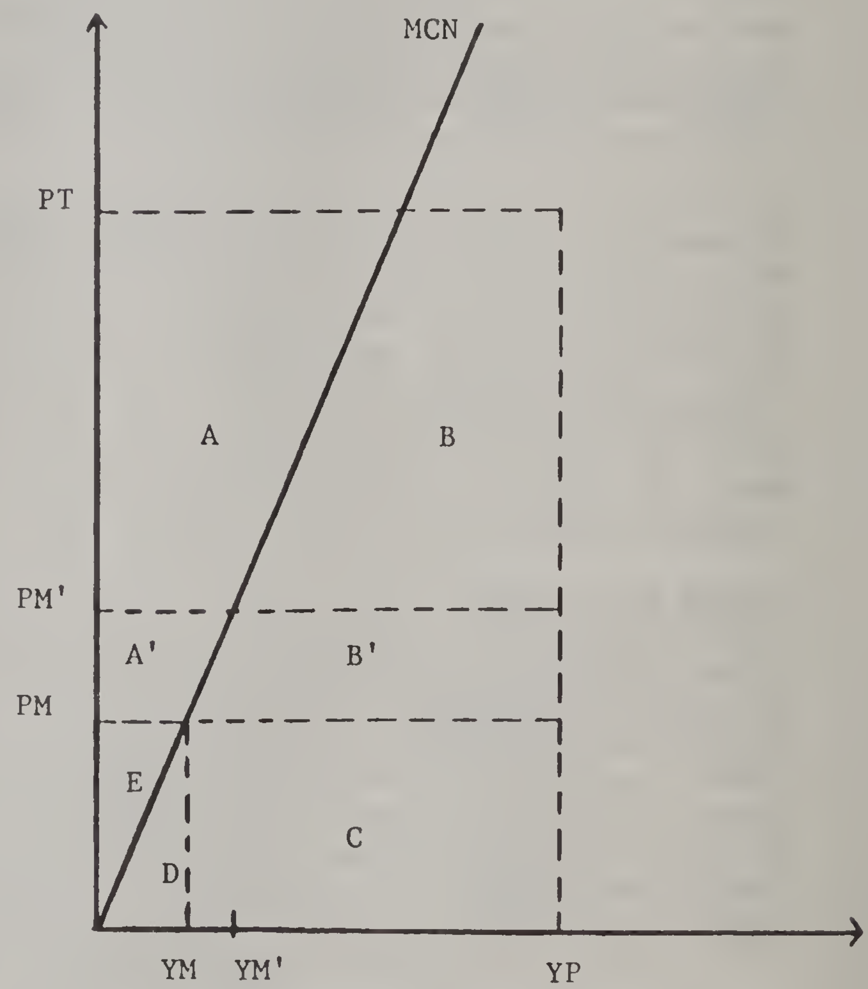
Panel A: Immediate update of program yields



Panel B: Delayed update of yields, stable supply



Panel C: Delayed update and technical change



Panel D: Nonproving participants

market revenues only rise by the area PM'*YM' - PM*YM. As a consequence of reduced revenues and higher costs, net returns on planted acreage for this nonproving participant fall by B'. Thus, nonproving program participants are the only group that does not benefit in the short run from the freeze on program payment yields.

In our sensitivity analysis discussed above (case II in table 3), we experimented with the case where participants chose between taking an average yield on the one hand and proving their yields on the other. In this case, the reduction in net returns for nonprovers was quite small ($0.31 per acre). Of course, by introducing the possibility of nonprovers (and deflating the incentive price with Z = 2/3), the effect of the freeze on output and market prices is reduced. This price reduction lowers the benefits to nonparticipants, whose net returns rise by $5.42 per acre in case II (in comparison with $10.77 per acre in case I, as depicted in table 5).

Results of Unfreezing Yields

Up to this point, we have been engaged in historical analysis. However, the most pressing question pertains to the likely consequences of unfreezing program payment yields. In order to examine this, we constructed a new, hypothetical crop year, which we call "1991." This is based on an expected market price from early 1990 and program parameters from the 1990 crop year. Potential yields are extrapolated from our model's 1986 base using the historical trend of 2 percent per year. However, actual yields in the hypothetical 1991 base are lower than their weather-adjusted counterpart in 1986, due to our assumption that a permanent freeze has been put in place. As a consequence, when we simulate the effects of removing this freeze, we will overstate the true consequences, since the current freeze is by no means perceived as being permanent. Finally, the land base for this hypothetical year has been reduced to abstract from land committed to the Conservation Reserve Program and the 50/92 option (which we have not modeled), based on data from the 1989 crop year. A comparison of key features of the 1986 and hypothetical 1991 bases is provided in table 6. Under these circumstances, our model projects a 76-percent participation rate in the basic wheat program. This projection is likely to be an underestimate if the 0/92 and overplanting options are actually made available to producers in 1991.

Consequences

The estimated consequences of permanently unfreezing program payment yields for wheat before the 1991 crop year are reported in the first column of table 7 (case I). Here we have assumed once again that the target price is not

Table 6--Comparison of the 1986 crop year with the assumed 1991 scenario

Item	Unit	1986	1991 (hypothetical)
Program variables:			
Target price	Dollars	4.38	4.00
Set-aside requirement	Percent	22.50	5.00
Paid land diversion	do.	6.00	--
Paid land diversion payment	do.	1.55	--
Expected market price	do.	2.54	3.10
Technology index	Index	100.00	110.00
Participation rate	Percent	73.26	76.00
Total land in sector	Mil. acres	91.00	82.80
Planted acreage	do.	72.00	79.66
Average yield	Index	100.00	84.01
Average input use	do.	100.00	73.01
Quantity share of exports	Percent	55.00	53.00

-- = Not applicable.

Table 7--Implications of an unanticipated, permanent unfreeze in program payment yields for U.S. wheat prior to the hypothetical 1991 crop year

Variable	Case I (Z = 1)	Case II (Z = 2/3 and nonprovers present)
	Percentage change	
Variable inputs:		
Per planted acre	20	8
Total use	20	8
Output (quantity)	10	4
Exports (quantity)	15	6
Participating acreage	7	7
Average annual return to land	-24	-12

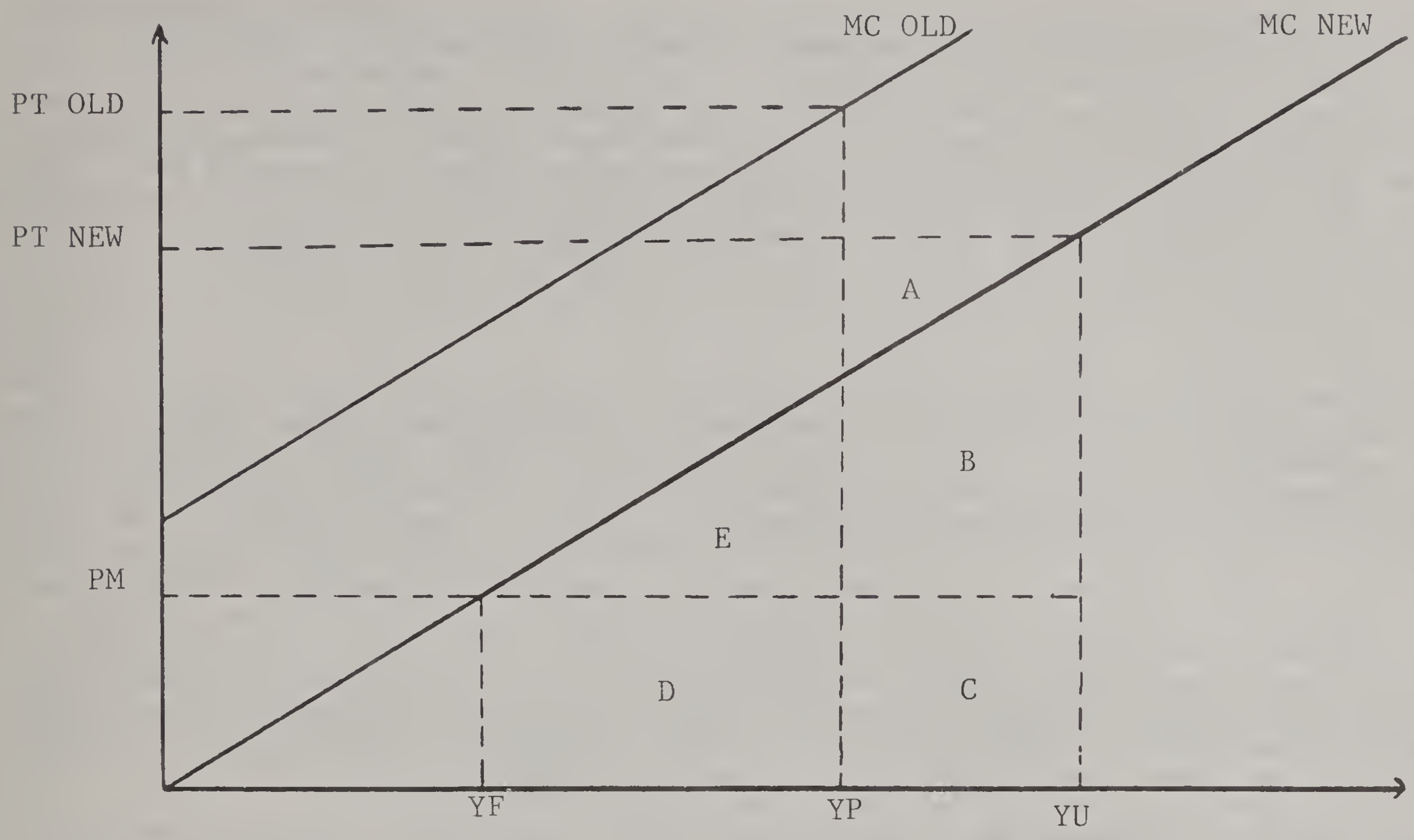
discounted and that all participants prove their yields in the absence of a freeze. The immediate effect of program participants' readopting the target price as their incentive price is an increase in variable input use. (This increase is somewhat less than the decrease in 1986 after the freeze, because of the smaller gap between the target and market prices.) Output also increases, which reduces the market price and increases the expected benefits of participation. Thus, the impact of unfreezing program payment yields reverses the effects of the freeze. Even though aggregate sectoral revenues increase, variable expenses increase more, and net returns fall. This drop is largest for nonparticipants, who face a falling market price without the prospects of increased deficiency payments.

The decrease in net returns following the unfreezing of program payment yields is truly surprising. Those who have proposed such a measure clearly have not had in mind the possibility that this unfreezing might make farmers worse off. How robust is this result? What does it depend on? Once again, simplified analysis by graphs will be helpful. Figure 5 presents the situation of the yield prover before and after the hypothetical 1991 unfreeze. For simplicity, it is assumed that Z = 1, so that the target price is the incentive price (case I). However, the particular value of Z chosen does not affect the following analysis.

In figure 5, program yields are frozen at YP. These were proved by this particular participant in an era of higher target prices (PT OLD) but less sophisticated technology (MC OLD). That is, they represented the intersection of MC OLD and PT OLD. In the hypothetical 1991 scenario, the target price has fallen to PT NEW, but potential yields have increased due to better varieties and other technological improvements which have shifted MC OLD out to MC NEW. The way this figure is drawn, the particular producer in question will now prove a higher yield, if given the chance, despite the lower target price of YU > YP. However, the presence of the current program yield freeze discourages him from doing so. In a particularly extreme case, the producer assumes that the freeze will be permanent, in which case output is given by YF.

The change in net returns following an unfreezing of program yields depends critically on the relationship between YU, YP, and YF. As drawn in figure 5, this yield-proving participant experiences a drop in net revenues. This is because the increased costs associated with proving higher yields (C + D + E + B) outweigh the sum of increased receipts from the market (C + D) and from deficiency payments (A + B). The difference between the two--the change in net returns--equals A - E. If MC NEW is roughly linear between YF and YU, then YP < 1/2(YU + YF), means that A will exceed E, and net returns will rise.

Figure 5 The impact on net returns of unfreezing program payment yields



Several factors will make such an increase in net returns more likely following the unfreezing of program yields. First, if the technology-induced shift from MC OLD to MC NEW is large relative to the effect on yields due to a diminished incentive price, then YU moves to the right, and the area of A increases. Second, if this yield prover does not believe the current freeze is permanent, then actual yields lie to the right of YF, and the area of E diminishes. Both of these will increase the probability that A > E, that is, that net returns to participants will rise following the unfreezing of program yields.

Finally, it is useful to conduct some sensitivity analysis with respect to the value of Z and the presence of nonproving participants. Since freezing yields has a smaller impact when Z = 2/3 and nonprovers are present, we expect the unfreezing of program payment yields also to be less significant in this case. And, indeed, this is true, as is demonstrated in the second column of table 7 (case II). In this case, variable input use rises by only 8 percent and net returns fall by 12 percent.

Not only does the increase in variable expenses (following the unfreezing of yields) lower net returns, it is also unattractive from an environmental point of view. Raising the incentive price for program participants brings about precisely the kind of Government-induced intensification of production environmental groups have criticized. Furthermore, it increases exports at the very time that the United States is lobbying other nations to reduce trade-distorting subsidies. In sum, there seems to be little to recommend this policy option.[10]

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[10]One frequent argument in favor of unfreezing yields--and one which has not been dealt with here--involves the issue of horizontal equity. Because the 1981-85 average did not necessarily freeze yields on farms of equal capacity at the same level, some observers argue that unfreezing is necessary to rectify this matter. But this paper argues that unfreezing yields is a poor instrument for achieving such a goal. It would be better to adjust yields based on a factor unrelated to current practices. One possibility would be to adjust the yields based on soil and climatic characteristics.

Alternatives

Since unfreezing program payment yields is such an unattractive policy, it is important to consider whether preferable alternatives exist, if Congress should seek to increase direct payments to producers. Since the intensification problem stems from altering farmers' perceived incentive prices, a preferable alternative would be one that preserves the market price as the relevant decision variable for program participants. What if the frozen 1981-85 yields were simply adjusted upwards by a common factor based on congressional intent to raise deficiency payments? In this situation, relative levels of program yields still remain frozen, and individual producers have nothing to gain by "proving" yields that are higher than would be justified by the market price.

Table 8 reports a comparison of the effect of unfreezing yields on key variables relative to that of the "indexation" alternative. Both sets of calculations are based on case II, the scenario in which deficiency payments are discounted and nonprovers are present. In the indexation case, all program yields are automatically raised by 7 percent. This happens to be the amount that would leave total deficiency payments to current participants unchanged. The results in this table are all reported in ratios of the value of a variable in the unfrozen case divided by the value of the same variable when yields remain frozen but are indexed upwards. Note that the composition of participant receipts changes, with slightly more revenue coming from the marketplace in the "unfreeze" case. Since participant variable costs are much higher in the unfreeze case, net returns are lower--only 87 percent of what they would be under the indexation alternative (0.87 x 100).

Not only are participants much better off under indexation of frozen yields, net returns for nonparticipants are also higher. The latter group is not forced to sell wheat on a market glutted by producers who are taking the $4 per bushel target price into account when making their variable input decisions. The final column in table 8 reports the results for all producers combined. There is little doubt that, should Congress seek to raise program yields, the indexation alternative is preferable from the point of view of environmental groups, the international trade negotiations, and farmers.

Table 8--A comparison of unfreezing program yields with alternative policies: Ratio of the two outcomes for case II (unfreeze/indexation)

Item	Participants	Others	All producers
		Ratio	
Total receipts	1.00	0.88	0.97
Market	1.00	.88	.96
Deficiency payments	1.00	1.00	1.00
Costs:			
Variable inputs	1.16	.92	1.09
Transactions	1.00	.95	1.00
Net returns	.87	.84	.86
Acres:			
Total	1.00	1.00	1.00
Planted	1.00	1.00	1.00
Returns per acre	.87	.84	.86
Output	1.08	.95	1.04
Exports	--	--	1.07

-- = Not available.

Summary and Conclusions

This paper has provided both a qualitative and quantitative assessment of the potential significance of the freeze on program yields for U.S. crops. Because of the differential effect such a measure has on heterogeneous producers, most existing models of the grains sector are unable to quantify its probable effect. For this reason, we have developed a new framework in which the inherent heterogeneity of producers is captured by continuous distributions for both land capacity and transaction costs. This model gives rise to an equilibrium in which some farmers choose to participate in the Government programs, while others do not.

The model is fitted to data from the U.S. wheat sector for the 1978, 1982, and 1986 crop years. By observing historical behavior in these 3 years, each with substantially differing program parameters and participation rates, we are able to make inferences about the unobserved distribution of land capacities and transaction costs. We simulate the shortrun effects of a permanent, unanticipated yield freeze in 1982 and 1986. In both cases, the freeze lowers the rate of nonland input use and raises the market price of wheat. Secondary effects are a lower program participation rate and higher net returns, and, hence, higher returns to land.

We also examine effects of unfreezing program yields, a step which some commodity groups had attempted to incorporate in the 1990 farm bill. In this case, the above mechanisms operate in reverse, with variable input use and output rising and wheat prices falling. This translates into higher budget costs, more potential environmental damage, and increased tension in world wheat markets. None of these effects seem desirable, yet there was pressure to unfreeze yields. Probably, producer groups recognize that the only way to maintain deficiency payments in the face of declining target prices is to raise program yields.

While this paper does not address the question of the appropriate amount of income transfer to grain producers, it does highlight the problems of achieving such a transfer by the means of unfreezing program yields. We demonstrate alternative mechanisms for maintaining the level of payments to grain producers which would not be so detrimental and which would result in far higher net returns for producers. As an example, we have suggested that program yields could be adjusted by some general index. As long as this index is not individual-specific, it would circumvent the intensification effect which would be unleashed if the freeze should be abolished in the future.

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Appendix: Technical Aspects of the Model

This appendix develops some of the technical aspects of the model used in this paper. For additional discussion and further details, the reader is referred to Tsigas, Hertel, and Preckel (10).

The Decision Problem

In the model, a manager's decision on whether to participate in the commodity program is based on profitability. For a given production unit with land area A, choice variables are the level of nonland inputs, $X_{i,r}$, which enter into the production function $h(\cdot)$, and the discrete variable i, which indicates whether the production unit is "in" or "out" of the commodity program. Convex transaction costs associated with participation are denoted T(r). The index of land capacity is denoted by e, and r is the homogeneity index associated with a given producing unit. The continuous distribution of land in the sector is described by f(e,r). The profit maximization problem for any particular production unit is given by:

$$\max_{i,X_{i,r}} g(i,X_{i,r}), \text{ which is given by:} \tag{1}$$

$$\int_{v_r}^{\bar{e}_r} \{P_T e\ h(A,X_{i,r}) - W_X X_{i,r}\} f(e,r)de - T(r), \qquad \text{for } i = \text{in, or}$$

$$\int_{\underline{e}_r}^{\bar{e}_r} \{P_M e\ h(A,X_{i,r}) - W_X X_{i,r}\} f(e,r)de, \qquad \text{for } i = \text{out.}$$

Note that in (1) we are assuming that program yields are unfrozen and that the relevant supply price for participants is the target price (P_T). We abstract from the lag caused by the 5-year moving average used to construct program yields. This assumption is relaxed in the analysis presented by graphs in the text.

In the limits of integration in (1), the lower and upper bounds on capacity indices for a given unit r are given by $\underline{e}_r$ and $\bar{e}_r$. If all land is planted (that is, if i = out), then these are the relevant limits of integration; all output is sold at the market price, P_M. However, if the producer chooses to enter the program in order to receive the target price, P_T, on each bushel of output, then the poorest land will not be planted. In this case, the lower limit of integration (v_r) is determined by the following condition:

$$\int_{\underline{e}_r}^{v_r} f(e,r)de = s \int_{\underline{e}_r}^{\bar{e}_r} f(e,r)de, \quad 0 \le s \le 1, \tag{2}$$

where s is the set-aside requirement.

The Land Base

As noted in the text, we make some simplifying assumptions on f(e,r). In particular, it is assumed that: First, for a given r, land capacity is uniformly distributed, that is, the conditional distribution of e, $f_c(e|r)$ is

$(\bar{e}_r - \underline{e}_r)^{-1}$, and, second the marginal distribution of r, $f_r(r)$ is $\gamma + \delta r$ for $0 \le r \le 1$. Since, $f(e,r)$ is equal to the product of $f_e(e|r)$ and $f_r(r)$, these assumptions imply that:

$$v_r = \underline{e}_r + s(\bar{e}_r - \underline{e}_r), \text{ and}$$

$$\mu_{in,r} = \mu_{out,r} + 0.5(\Delta_e)s,$$

where $\Delta_e \equiv (\bar{e}_r - \underline{e}_r)$, $\mu_{in,r}$ and $\mu_{out,r}$ denote the mean land capacity for production unit r under participation and nonparticipation, respectively $[\mu_{out,r} = 0.5(\bar{e}_r + \underline{e}_r)]$. Finally, the relationship between mean capacity and the homogeneity index is assumed to be cubic in form.

The Production Function

Before leaving discussion of (1), a few observations about the grains production function itself are in order. First of all, note that the capacity index, e, is defined as a neutral shift in h(A,X). It accounts for differences in output which persist after land area and variable nonland input levels are accounted for. The production function is assumed to have a constant elasticity of substitution. For convenience, the substitution parameter (σ) is assumed to be invariant to e. However, alternative specifications may merit exploration in the future. Setting A equal to unity, this results in the following per acre production function:

$$h(1,X_{i,r}) = \alpha[1 + \beta X_{i,r}^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)}. \tag{3}$$

The parameter α is adjusted to account for technological change over the period of observation, based on the relationship estimated by Ash and Lin (2).

Transaction Costs

Per acre transaction costs are given by:

$$T(r) = \theta * [r/(1 - r)], \tag{4}$$

where the parameter θ in (4) is constrained to be positive, so that transaction costs are an increasing function of the homogeneity index r, that is, $T'(r) > 0$ and $T''(r) > 0$.

Determination of Sectoral Supply and Demand

The entire sector's land base (L) may be obtained by calculating the volume of the land distribution:

$$L = \int_0^1 \int_{\underline{e}_r}^{\bar{e}_r} f(e,r)\,de\,dr. \tag{5}$$

When this aggregation is performed, a critical point, r*, will be present in the acreage distribution, at which point the marginal participant is indifferent between being in or out of the program; that is:

$$g(in, X^*_{in,r^*}) = g(out, X^*_{out,r^*}), \tag{6}$$

where X* denotes the optimal level of nonland input use at r*, as determined by (1). As a consequence of this formulation, the sector-wide profit maximization problem reduces to a problem of finding r* and computing the optimal distribution of nonland inputs: $X^*_{i,r}$. This is summarized in (7):

$$R = \max_{r^*, X_{i,r}} \int_0^{r^*} \int_{v_r}^{\bar{e}_r} \{P_T e\ h(1, X_{in,r}) - W_X X_{in,r}\} f(e,r) de\ dr - \int_0^{r^*} T(r) dr$$

$$+ \int_{r^*}^{1} \int_{\underline{e}_r}^{\bar{e}_r} \{P_M e\ h(1, X_{out,r}) - W_X X_{out,r}\} f(e,r) de\ dr. \tag{7}$$

Recognizing the fact that production decisions do not take place on an acre-by-acre basis, we assume that $X^*_{in,r}$ and $X^*_{out,r}$ do not depend on e. That is, for a given r, managers do not vary the optimum quantity of nonland inputs as e varies between its lower and upper limits. Instead, we assume that the rate of nonland input use depends only on the mean quality of land in a given field or producing unit. From (7), integrating over e and substituting in $X^*_{in,r}$ and $X^*_{out,r}$, we obtain:

$$\begin{aligned} R = \max_{r^*} (1-s) \int_0^{r^*} \{P_T h(1, X^*_{in,r}) \mu_{in,r} - W_X X^*_{in,r}\} (\gamma + \delta r) dr \\ - \int_0^{r^*} T(r) dr + \int_{r^*}^{1} \{P_M h(1, X^*_{out,r}) \mu_{out,r} - W_X X^*_{out,r}\} (\gamma + \delta r) dr. \end{aligned} \tag{8}$$

Notice that r* is a continuous variable, $0 \le r^* \le 1$. The value r* is determined by $\partial R / \partial r^* = 0$ (with $\frac{\partial^2 R}{\partial r^{*2}} < 0$). This indifference condition (6) may now be written as follows:

$$\begin{aligned} (1-s)\{P_T h(1, X^*_{in,r}) \mu_{in,r^*} - W_X X^*_{in,r^*}\} - T(r^*) = \\ P_M h(1, X^*_{out,r^*}) \mu_{out,r^*} - W_X X^*_{out,r^*}. \end{aligned} \tag{9}$$

The farm level demand for output is assumed to be of constant elasticity form, while the aggregate supply of wheat (Y^S) and the demand for nonland inputs (X^D) are given by (10) and (11):

$$Y^S = \int_0^{r^*} \int_{v_r}^{\bar{e}_r} e\ h(1, X^*_{in,r}) f(e,r) de\ dr + \int_{r^*}^{1} \int_{\underline{e}_r}^{\bar{e}_r} e\ h(1, X^*_{out,r}) f(e,r) de\ dr, \tag{10}$$

and

$$X^D = \int_0^{r^*} \int_{\nu_r}^{\bar{e}_r} X^*_{in,r}\ f(e,r)de\ dr + \int_{r^*}^{1} \int_{\underline{e}_r}^{\bar{e}_r} X^*_{out,r}\ f(e,r)de\ dr. \tag{11}$$

Finally, although the model generates a complete distribution of land rents, it is often desirable to report an average rental rate on land. This is computed as follows:

$$W_L = R/L. \tag{12}$$

Model Estimation

The specific estimation procedure employed is motivated by the work of Kydland and Prescott on real business cycles (5). We choose to minimize the weighted sum of squared errors:

$$\sum_i \sum_t (\hat{Y}_{i,t} - Y_{i,t})^2 / S_i, \tag{13}$$

where the weights, $S_i = \Sigma_t (Y^o_{i,t} - Y_{i,t})^2$, are specific to each of the variables being fitted. To clarify notation, $\hat{Y}_{i,t}$ is the fitted value for variable i in year t, $Y_{i,t}$ is the observed value, and $Y^o_{i,t}$ is the model's initial prediction based on starting values for the parameters to be estimated. Subscripts t = 1978, 1982, and 1986, and i = sectoral output, variable cash expenses, and participants' share in total output. All data are reported in table 1 of the text.

There is also a set of constraints associated with this problem. Most of these simply restrict parameters to have reasonable signs. For example, distributive shares and the elasticity of substitution in production must be positive. However, several constraints add important economic content. In particular, we require that the marginal participant ($r = r^*$) be indifferent between being in or out of the program in each of the 3 years. We also force the distribution of mean capacities to have the general shape discussed in the text (that is, $\mu_e(r)$ decreasing for r larger than 0.73). Finally, we require predicted and observed land use to be equal.

Appendix table 1 reports the values of the fitted model parameters and the discrepancies between predicted and observed values of output, variable input use and participants' output share.

Appendix table 1--The fitted model

A. Parameter estimates

$\sigma = 0.591$ $\quad\theta = 12.8$

$\alpha = 54.7$ $\quad\epsilon = 3.4$

$\beta = 0.394$ $\quad\delta_{1978} = -40.6$

$W_x = 64.5$ $\quad\delta_{1982,\ 1986} = 4.43$

$\bar{e}_r = 1.90 - .947r + 4.06r^2 - 4.01r^3$

$\underline{e}_r = .0227 - .349r + 1.41r^2 - .0857^3$

	1972	1982	1986
B. Model predictions[1]:			
Weather-adjusted output in millions of bushels	2,185 (18.4)	2,830 (2.34)	1,825 (-18.8)
Variable cash expenses in 1982 dollars per planted acre	50.70 (18.8)	43.57 (-18.8)	55.21 (9.94)
Participants' production share	.6022 (-9.89)	.3813 (11.0)	.7869 (-6.04)

[1]Percentage deviations from observed values in parentheses.

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